Features of Supply of Telecommunications in the Arctic

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Abstract — **For the Arctic exploration it is necessary to provide polar explorers with reliable high-quality communication equipment: satellite complex, router, wireless network. To supply with communications equipment and computer network a stable power supply is needed. A possible solution of the problem is the usage of alternative energy sources (solar panels, wind generators, batteries). In this paper we study the possibility of installing the system in the Arctic for making alternative power supply. Tests showed that during polar day the best way is to use solar panels, during the polar night vertical wind turbines are better.**

Keywords - Alterntive energy; Remote data collection; Python; Raspberry Pi; Rsync.

I. Introduction

The NARFU [1] mission aims at formation and development of competitive human capital in the North-West Federal Region through creation and implementation of innovative services as well as at the outlooks development of the Russian North and the Arctic. For this mission accomplishment NARFU has highly skilled experts, high-tech equipment, ability to introduce new developments in the production and achieve desired result. Russian government charged NARFU with carrying out comprehensive research in the Arctic.

Presently, Russian Federation's priorities are energy management and energy saving. The Arctic is of extremely important military-strategic significance for Russia. A fundamental problem facing humanity is the energy problem. Currently, the main sources of energy are coal, oil and gas. Their forecasted reserves are estimated in 15 trillion tons, 500 billion tons and 400 trillion tons respectively. At the present production level given coal reserves will last out for 400 years, oil ones will do for 42 years and gas for 61 years [2]. The world's energy system is facing huge problems. Natural energy resources go through rapid depletion. The task of finding new ways to get energy isin the forefront so that in the short term oil, natural gas and coal [3] consumption would be reduced.

For the long time the traditional sources of electricity for the Arctic zone were gas and diesel generators. Both requires regular delivery of fuel and maintenance. In addition, as a result of this activity there is a significant negative influence on the ecology of islands in the Arctic Ocean, such as pollution by exhausts [WU1], fuel spill on the soil surface during fuel transportation leading to vegetation removal, amassing of excessive containers.

Planning the Arctic exploration it is necessary to provide polar explorers with reliable high-quality communication, such as: satellite complex, router, wireless network. Power required to supply the equipment should not be less than 180W. Also, planning the communications equipment supply and computer network one needs to provide a stable power supply. A possible problem solution is the usage of alternative energy sources (solar panels, wind generators, or batteries).

II. Calculation of the Energy and Installation

The designed system block diagram is shown in Fig.1.

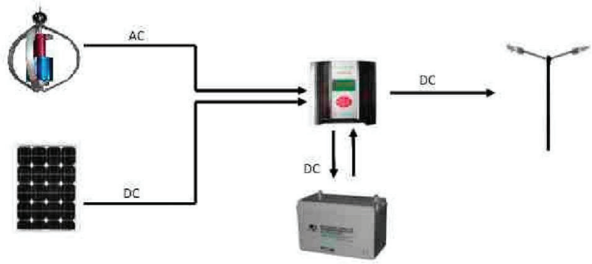

Fig. 1. Flowchart of projected Position

The structure of the power block includes:

- Inverter MUST EP 3000 2024 power up to 2000W.
- 4 Maintenance free batteries 12 CHALLENGER G-200H with a nominal voltage of 12V, 200Ah capacity connected in two parallel branches with 2 batteries in each of them. Finally, we get the battery pack with nominal voltage of 24V and capacity of 400Ah.
- Wind turbine WH200-20 HS-24 Whisper 200 with charge controller. Factory settings of controller: 26.8 - 28.8V are ideal for working with lead batteries, you can connect batteries directly to the output of the wind turbine. At a voltage less than 26.8V battery charging starts; when voltage reaches 28.8V charging stops.

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- FSM 300 solar module with 300W maximum power at a voltage Vmp = 36.7V and a current Imp = 8.17A. Open circuit voltage Voc = 45.5V, short circuit current Isc = 8.83A. Batteries are connected to solar panels through the controller.
- Charge Controller Morningstar TS-MPPT-60 should be set to the output voltage of 26.8 - 28.8V to be able to connect it directly to the battery output.

A current from a windmill and solar panels under the steerage of the controller charges batteries. At a certain load power it is possible to calculate the current consumed by the inverter MUST EP 3000 2024 from the battery pack from the formula:

$$P_l = UI\eta, where \quad \eta - \text{efficiency of the inverter} \qquad (1)$$

Hence, the maximum current consumption is calculated

$$I_{\max} = \frac{P_{\max}}{U\eta} = \frac{1500}{24 \cdot 0.95} = 66A \qquad (2)$$

The graph of inverter input current dependence on the load power presented in Fig.2 shows that the Efficiency of inverter is constant linear function s.

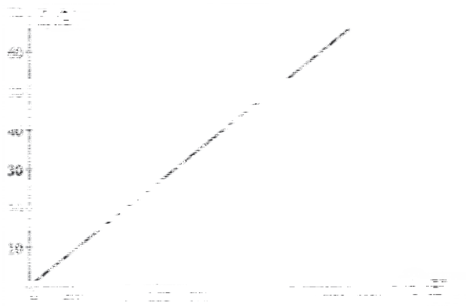

Fig. 2. Graph of current from the power load

When the inverter supplies the energy only from the battery pack operating time is limited. The planning full charge battery usage time depends on the discharge current. According to the documents of battery Challenger G12-200H its final discharge voltage for 200 Ah capacity is 1.75V at 1 element that is 1.75x6 = 10.5V on the battery [4]. The dependence of the total discharge on the discharge current for the final voltage of 10.5V is given in Table 1.

TABLE 1. TIME DEPENDENCE OF FULL DISCHARGE ON THE DISCHARGE CURRENT

T, h	2	3	4	5	8	10	20
I, A	67.7	51.5	40.9	34.0	23.1	18.8	10.1

In a parallel operating the battery discharge current is doubled. With this in mind, we draw a graph with the dependence of the total discharge on the discharge current (input current of the inverter) for the current range of interest up to 100A. For small currents, less than 20A, discharge time can be calculated by a simple formula (Fig.3):

$$T_{\text{discharge(p)}} = \frac{\text{Capacity (Ah)}}{I(A)} \qquad (3)$$

With a maximum load power 1500W, the batteries are fully discharged for 5.2h. An operating wind turbine reduces current consumption from the battery and extends the battery life of batteries.

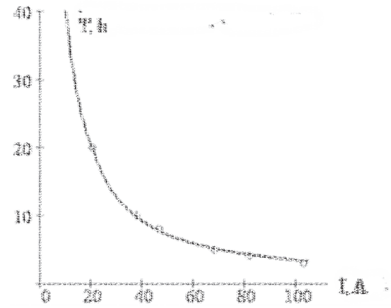

Fig. 3. Graph discharge (Option 1)

The maximum capacity of wind turbines at a wind speed 11.6 m / s is 1000W; the current generator wherein:

$$I_{\max} = \frac{P_{\max}}{U_g} = \frac{1000}{24} \approx 42A \qquad (4)$$

The graph of total discharge time of the input current of the inverter is shown in Fig.4.

At the maximum load power of 1500W, the batteries are fully discharged in 17h. When the inverter input current is less than 42A, the corresponding to the load power less than 950W, the batteries are charged.

At a wind speed 5.4 m/s, the wind turbine generates 158kWh of energy per month, which corresponds to the average power Pg=1000·158/(24·30)≈220W, and give, in current, Ig=220/24≈9.1A. Accordingly, when the input current is less than 9.1A (load power less than 207W), the batteries will be recharged. At the maximum load power 1500W, the batteries are fully discharged in 6.3h (Fig.5).

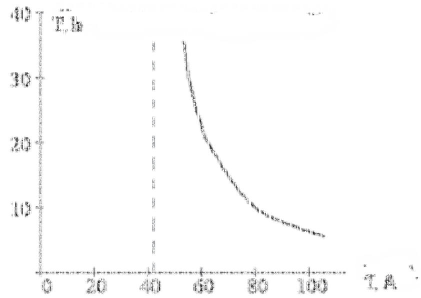

Fig. 4. Graph discharge (Option 2)

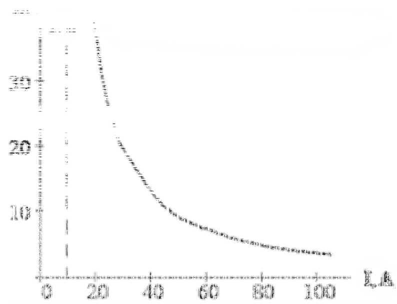

Fig. 5. Graph discharge (Option 3)

Additionally, the connected solar module, under the best conditions (300W maximum power output of it), gives a total load of not more than Imp = 8.17A. When combined with a generator, when the wind speed 11.6 m/s, the total currentis 8.17 +42 ≈ 50A. Dependence of the battery is fully discharged from the input current of the inverter (Fig.6).

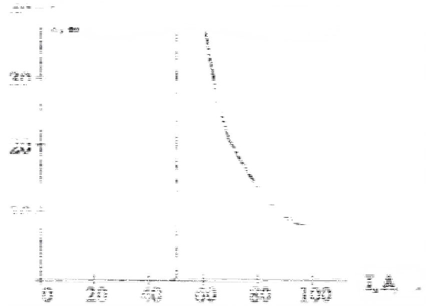

Fig. 6. Graph discharge (Option 4)

At the maximum load power of 1500W, the batteries are fully discharged in 24h. When the inverter input current is less than 50A, corresponding to the load power less than 1140W, the batteries are charged.

At a wind speed of 5.4 m/s, the wind turbine produces Ig≈9.1A; when combined with the generator module of the total current is 8.17+9.1≈17.2A. At the maximum load power of 1500W, the batteries are fully discharged in 7.5hour. When the inverter input current is less than 17.2A, corresponding to the load power less than 395W, the batteries are charged. The calculations are estimates and require experimental verification.

The results of calculations are shown in Tables 2-3.

TABLE 2. MAXIMUM LOAD 1500W CAN SUPPORT EQUIPMENT OFFERS A LIMITED TIME

View Source	T, h
Batteries	5.2
Batteries + wind generator (5.4 m / s)	6.3
Batteries + Solar module (calm, <3.1 m / s)	6.2
Batteries + wind generator (5.4 m / s) + solar module	7.5
Batteries + wind turbine (11.6 m / s)	17
Batteries + wind turbine (11.6 m / s) + solar module	24

TABLE 3. MAXIMUM POWER LOAD AT WHICH CONSERVING BATTERY POWER

View Source	P, W
Batteries + Solar module (calm, <3.1 m / s)	185
Batteries + wind generator (5.4 m / s) + solar module	207
Batteries + wind turbine (11.6 m / s)	395
Batteries + Solar module (calm, <3.1 m / s)	950
Batteries + wind turbine (11.6 m / s) + solar module	1140

III. MONITORING FEATURES TRISTAR-60 MPPT

To control the unit of solar panels used solar panels charge controller Tristar-60 MPPT. It has Ethernet interface with the ability to connect to a LAN. In this case, the controller was placed in the Internet with direct access using a satellite channel [5][6].

The controller has a web interface to configure and monitor the readings. However, for our purposes it was unusable because with its help we can get either the instantaneous values or historical data, averaged per day. Daily readings did not provide sufficient information about the dynamics of the system, so we had to remove periodically the instant indicators and write them to the database. As we did not find other ways to get data other than over a web interface in the manufacturer's documentation, we decided to use it as a data source.

Due to the high cost of the data channel, it was necessary to minimize bandwidth consumption by the acquisition system. It was impossible to use different traffic compression technologies due to the fact that on the experimental point it has not been possible to install a compression system. Therefore, it was decided to use direct access to the data source usingd the original web-based interface of the bypass. After analyzing the Javascript code of the original web interface, it was found that the data is obtained by performing a GET request through a CGI script and is returned as a simple text [7][8]. As a result, to make such a request special script was written in Python [9] for generating, parsing the data and writing the value into the databaseto save traffic data accumulated in memory. The script was put to run periodically every 5 minutes on one of our servers. Average bandwidth consumption was less than 2 megabytes per month including service traffic.

IV. ARCTIC EXPEDITION

The alternative energy system was delivered to the polar station FGBI "Russian Arctic National Park"(Cape Desire of North Island, Novaya Zemlya archipelago). The equipment and the staff of Radio Monitoring Center NARFU were taken on the research vessel "Professor Molchanov" of "Arctic Floating University 2013" project.

The installation of the equipment on place took 4 days. The main part of the installation has been made in the first three days, most of which was spent on the installation of the wind turbine, the last fourth day there was installation and tuning of controllers for power plant. The first two days of the expedition to Novaya Zemlya were devoted to installing a windmill.

When installing the mast a number of problems occurred, mainly because of the rocky soil hardness rocks and the presence of underground water that flooded the hole so the mast base could hardly be fixed. The mast basement was made of cement pad, the mast pole had tension ropes on it for better stiffness of the construction. This design has been recommended by the windmill manufacturer, but as it turned out later, the construction was not tested in the Arctic weather conditions, and it needs more rigid structure of the mast. In the third day, four solar panels on the roof of an apartment house using rigid metal parts, made of wire and connected to the controller management were installed. The fourth day consisted of installing batteries, total electrical circuit, controllers tuning, checking the battery performance, as well as connection of the inverter to provide a residential home network 220V from alternative energy sources.

V. SYSTEM TEST

After system startup collecting data was carried out remotely using satellite communication channel provided by "The Russian Satellite Communication Company (RSCC)" [10].

For power saving system used load resistance 120Ω and 260Ω. If an inverter output voltage is 220V, having these resistances power dissipation will be 403W and 186W respectively (this corresponds to the calculated parameters Table III). Rechargeable batteries were permanently charged. Tests were conducted in July and August. There is a polar day at this time in the latitude of 76. Energy stable flow is provided for solar panels to recharge the batteries and supply the load. The energy flow from the solar panels is shown in Fig.7.

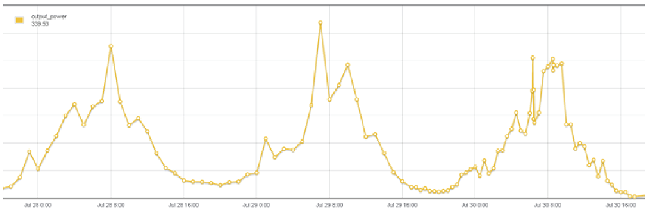

Fig. 7. Graph telemetry readings at Cape Desire

As seen from the graph the energy supply depends on day time . The maximum performance was at 8:00 AM (12:00 AM GMT). Indications are directly dependent on the latitude of the sun over the horizont. Energy input from the solar panels does not stop at night at the lowest location of the sun. Solar panels real capacity is only up to 50% of the claimed one. Cloudiness reduces power produced by solar panels. A low cloudiness has a small influence. High cloudiness reducessolar energy by 30-50%. The power is produced from the battery at night and during strong cloudiness. It is possible to recommend the use solar panels in the Arctic during the polar summer.

Horizontal wind turbine Whisper 200 [11] worked steadily. The strong wind constantly blows at a speed of more than 3 m / s on the Cape Wishes in the summer. Generated power changes in a range of 400-950W. A wind generator used to power communications equipment FGBI " Russian Arctic National Park". During the whole study period the power was stable. August 9, 2013 during sudden gusting of wind with speed over 27 m / s wind turbine was destroyed. The literature analysis, observation of our experts in the Arctic and the fact Whisper 200 wind turbine destruction led to the conclusion that the usage of horizontal generators in the Arctic is not recommended. It is better to use vertical wind turbines.

Monitoring program designed for controller Tristar-60 MPPT provided operational information remotely. The data was recorded in the database. This has enabled the analysis of evidence for the whole observation period.

VI. CONCLUSION

The Arctic is a priority for the Russian economy. Arctic exploration is impossible without high-quality and reliable communications. The diesel or petrol generators to supply communications equipment is commonly used. We suggest the usage of power communications equipment for alternative sources of energy.

We designed the alternative energy complex. The structure of the power block includes inverter MUST EP 3000 2024, 4 Maintenance free batteries CHALLENGER G 12-200H, wind turbine WH200-20 HS-24 Whisper 200, solar module FSM 300, Charge Controller Morningstar TS-MPPT-60. Preliminary calculations were made for processes of charge and discharge of batteries in different weather conditions.

System of alternative energy was delivered into a polar station of FGBI " Russian Arctic National Park" (Cape Desire of North Island, Novaya Zemlya archipelago). After system startup work for collecting data was carried out remotely using satellite communication channel provided by RSCC.

After tests, we can conclude that horizontal wind turbines usage under the conditions of northern latitudes can be irrational because of their instability to gusty winds. We suggest the vertical wind turbines. During the summer, wind turbines produce power stately.

Solar panels worked steadily in the summer, producing 50% of claimed power. The dependence of the power generated on the time of day is well traced. Peak power values occur in the period of 8-12 hours a day. Power, generated by the solar panels, depends on the cloudiness. The strong cloudiness drops power by 30-50%. However, in these moments the system begins to consume the energy stored in the batteries. Thus, the system performance is constant. In the Arctic a solar panels are more reliable. It is possible to recommend the installation of solar panels during the polar day. During the polar night it is better to use wind turbines. The created complex fully allows to feed with electricity the installation of satellite communications in the Arctic.

Required power in the amount of 180W supply for installation of communications equipment was provided. Previous evidence differs from the calculated capacity not more than in 20%.

Monitoring program designed for controller Tristar-60 MPPT provides operational information remotely. The data was recorded in the database. This allowed to analyze the evidence during the entire observation period.

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